

This Page Is Inserted by IFW Operations
and is not a part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

As rescanning documents *will not* correct images,
please do not report the images to the
Image Problem Mailbox.

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1 Claim 1 (original): A filter system for post-processing a digital image, said
2 digital image having a plurality of visual-edge pixels and a plurality of visual non-edge
3 pixels, said filter system comprising:

- 4 (a) an edge mapper for producing a binary map of said visual edge
5 pixels and said visual non-edge pixels;
- 6 (b) a pixel sorter comprising:
 - 7 (i) said pixel sorter for reading said binary map; and
 - 8 (ii) said pixel sorter for assigning to each pixel a type of filtration
9 to be provided by said filter system;
- 10 (c) an adaptive filter for receiving output from said pixel sorter; and
- 11 (d) said adaptive filter comprising:
 - 12 (i) a de-ringing module for post-processing said visual non-
13 edge pixels; and
 - 14 (ii) an edge sharpener for post-processing said edge pixels.

15
1 Claim 2 (original): The filter system of claim 1, said edge mapper further
2 comprising:

- 3 (a) an edge detector comprising:
 - 4 (i) said edge detector for calculating intensity gradients for each
5 pixel in said digital image;
 - 6 (ii) said edge detector for assigning a first edge value to each
7 edge pixel based on said intensity gradients; and

- (iii) said edge detector for assigning a second edge value to each non-edge pixel based on said intensity gradients; and
- (b) a memory storage array for storing said first edge value for each edge pixel and for storing said second edge value for each non-edge pixel.

Claim 3 (original): The filter system of claim 2, wherein said edge detector uses at least one edge detection operator to calculate said intensity gradients selected from the group of edge detection operators consisting of:

- (a) a Sobel edge detection operator;
- (b) a Prewitt edge detection operator; and
- (c) a Roberts edge detection operator.

Claim 4 (original): The filter system of claim 2, wherein said edge detector uses Roberts edge detection operators H_1 and H_2 of the form:

$$H_1 = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \quad H_2 = \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}.$$

Claim 5 (original): The filter system of claim 2, said edge detector for executing an edge value subroutine for calculating said first edge value for each visual edge pixel and said second edge value for each visual non-edge pixel, said edge value subroutine further comprising:

- (a) at least one edge detection operator for calculating intensity gradients for each pixel in said digital image;
- (b) an i variable for storing a horizontal coordinate of each pixel in said digital image;
- (c) a j variable for storing a vertical coordinate of each pixel in said digital image;

- 11 (d) $g_{H1}(i, j)$ and $g_{H2}(i, j)$ variables for storing intensity gradients
12 calculated by said at least one edge detection operator;
13 (e) an EdgeStrength(i, j) variable for storing an average of said
14 intensity gradients for each pixel in said digital image;
15 (f) an EdgeThreshold variable for storing a selectable threshold value
16 for defining a true visual edge containing said visual edge pixels;
17 and
18 (g) an EdgeValue(i, j) variable for storing said first edge value for each
19 visual edge pixel and said second edge value for each visual non-
20 edge pixel;
21 (h) wherein said edge value subroutine is defined as:
22 EdgeStrength(i, j) = ($|g_{H1}(i, j)| + |g_{H2}(i, j)|$)/2;
23 if (EdgeStrength(i, j) > EdgeThreshold)
24 {
25 EdgeValue(i, j) = 1;
26 }
27 else
28 {
29 EdgeValue(i, j) = 0;
30 }.

31
1 Claim 6 (original): The filter system of claim 2, said pixel sorter further
2 comprising:

- 3 (a) a first comparator for sorting said visual edge pixels from said
4 visual non-edge pixels;
5 (b) a selector comprising:
6 (i) said selector receiving output from said first comparator; and
7 (ii) said selector designating a kernel of pixels near each pixel
8 being processed; and

9 (c) a second comparator comprising:

10 (i) said second comparator receiving output from said selector;
11 and

12 (ii) said second comparator assigning types of filtration to each
13 pixel being processed based at least in part on a sum of first
14 edge values and second edge values of said pixels in said
15 kernel of pixels.

16
1 Claim 7 (original): The filter system of claim 6, wherein said kernel of
2 pixels is a grid of pixels in which said pixel being processed is a center pixel in said grid
3 of pixels.

4
1 Claim 8 (original): The filter system of claim 6, wherein said second
2 comparator is for applying de-ringing filtration by said de-ringing module to said pixel
3 being processed if said pixel being processed is a visual non-edge pixel and said sum
4 of first edge values and second edge values of said pixels in said kernel of pixels is less
5 than a predetermined threshold value defining a true visual edge.

6
1 Claim 9 (original): The filter system of claim 6, wherein said first
2 comparator is for applying edge sharpening filtration by said edge sharpener to said
3 pixel being processed if said pixel being processed is a visual edge pixel.

4
1 Claim 10 (original): The filter system of claim 6, said second comparator
2 applying no de-ringing filter and no edge sharpener to said pixel being processed if said
3 pixel being processed is a visual non-edge pixel based on said second edge value and
4 said sum of first edge values and second edge values of said pixels in said kernel of
5 pixels is not less than a predetermined threshold value defining a true visual edge.

1 Claim 11 (original): The filter system of claim 6, said filter system further
2 comprising:

- 3 (a) a grayscale;
- 4 (b) said grayscale for summing grayscale values of all visual edge
5 pixels in said kernel of pixels; and
- 6 (c) said grayscale summing grayscale values of all visual non-edge
7 pixels in said kernel of pixels.

1 Claim 12 (currently amended): ~~The filter system of claim 6,~~ A filter system
2 for post-processing a digital image, said digital image having a plurality of visual-edge
3 pixels and a plurality of visual non-edge pixels, said filter system comprising:

4 (a) an edge mapper for producing a binary map of said visual edge
5 pixels and said visual non-edge pixels, said edge mapper further comprising:

6 (i) an edge detector comprising:

7 (A) said edge detector for calculating intensity gradients
8 for each pixel in said digital image;

9 (B) said edge detector for assigning a first edge value to
10 each edge pixel based on said intensity gradients;
11 and

12 (C) said edge detector for assigning a second edge value
13 to each non-edge pixel based on said intensity
14 gradients; and

15 (ii) a memory storage array for storing said first edge value for
16 each edge pixel and for storing said second edge value for
17 each non-edge pixel;

18 (b) a pixel sorter comprising:

19 (i) said pixel sorter for reading said binary map;

20 (ii) said pixel sorter for assigning to each pixel a type of filtration
21 to be provided by said filter system; and

22 (iii) said pixel sorter further comprising:

23 (A) a first comparator for sorting said visual edge pixels
24 from said visual non-edge pixels;

25 (B) a selector comprising:

26 (1) said selector receiving output from said first
27 comparator; and

28 (2) said selector designating a kernel of pixels
29 near each pixel being processed; and

30 (C) a second comparator comprising:

31 (1) said second comparator receiving output from
32 said selector; and

33 (2) said second comparator assigning types of
34 filtration to each pixel being processed based
35 at least in part on a sum of first edge values
36 and second edge values of said pixels in said
37 kernel of pixels;

38 (c) an adaptive filter for receiving output from said pixel sorter, said
39 adaptive filter for executing a grayscale subroutine for counting said
40 number of visual edge pixels in said kernel of pixels, for summing
41 grayscale values of all visual edge pixels in said kernel of pixels,
42 and for summing grayscale values of all visual non-edge pixels in
43 said kernel of pixels, said grayscale subroutine further comprising:

44 i __[(a)] an i variable for storing a horizontal coordinate of
45 each pixel in said digital image;

46 ii __[(b)] a j variable for storing a vertical coordinate of each
47 pixel in said digital image;

48 iii __[(c)] an ix integer variable for counting a horizontal
49 distance away from said i variable;

iv [(d)] an jy integer variable for counting a vertical distance
away from said j variable;

v [(e)] an X integer variable for defining a length of a
horizontal edge of said kernel of pixels;

vi [(f)] a Y integer variable for defining a length of a vertical
edge of said kernel of pixels;

vii [(g)] a Kernel variable for storing a count of pixels in said
kernel of pixels obtained by multiplying said X integer by said
Y integer;

viii [(h)] a NonEdgeGrayscaleSum variable for storing said
sum of grayscale values of all visual non-edge pixels in said
kernel of pixels;

ix [(i)] an EdgeGrayscaleSum variable for storing said sum
of grayscale values of all visual edge pixels in said kernel of
pixels;

x [(j)] an EdgeValue(i, j) variable for storing said first edge
value for each visual edge pixel and for storing said second
edge value for each visual non-edge pixel;

xi [(k)] a Grayscale(i, j) variable for storing a grayscale value
of each pixel located at coordinates i and j in said digital
image; and

xii [(l)] a SumEdgePixels variable for counting a number of
said visual edge pixels in said kernel of pixels;

xiii [(m)] wherein said grayscale subroutine is defined as:
Kernel = (2 * X + 1) * (2 * Y + 1);
NonEdgeGrayscaleSum = EdgeGrayscaleSum = 0;
for(ix = - X; ix <= X; ix++)
for(jy = - Y; jy <= Y; jy++)
{

79 NonEdgeGrayscaleSum += (1 - EdgeValue(i + ix, j + jy)) *
80 GrayScale(i + ix, j + jy);
81 EdgeGrayscaleSum += EdgeValue(i + ix, j + jy) * GrayScale(i + ix, j
82 + jy);
83 SumEdgePixels += EdgeValue(i + ix, j + jy);
84 }; and

85 (d) said adaptive filter comprising:
86 (i) a de-ringing module for post-processing said visual non-
87 edge pixels; and
88 (ii) an edge sharpener for post-processing said edge pixels.

89

1 Claim 13 (original): The filter system of claim 1, said de-ringing module
2 further comprising a weighting module; said weighting module altering a grayscale value
3 of each visual non-edge pixel for final display in direct proportion to an average
4 grayscale value of all visual non-edge pixels in a kernel of pixels.

5

1 Claim 14 (original): The filter system of claim 13, said average grayscale
2 value further comprising:

3 (a) a sum of grayscale values from said all visual non-edge pixels in
4 said kernel of pixels;
5 (b) said sum divided by a number of said all visual non-edge pixels in a
6 kernel of pixels.

7

1 Claim 15 (currently amended): ~~The filter system of claim 14,~~ A filter
2 system for post-processing a digital image, said digital image having a plurality of
3 visual-edge pixels and a plurality of visual non-edge pixels, said filter system
4 comprising:

5 (a) an edge mapper for producing a binary map of said visual edge
6 pixels and said visual non-edge pixels;

- 7 (b) a pixel sorter comprising:
8 (i) said pixel sorter for reading said binary map; and
9 (ii) said pixel sorter for assigning to each pixel a type of filtration
10 to be provided by said filter system;
11 (c) an adaptive filter for receiving output from said pixel sorter; and
12 (d) said adaptive filter comprising:
13 (i) a de-ringing module for post-processing said visual non-
14 edge pixels, said de-ringing module further comprising a
15 weighting module, said weighting module altering a
16 grayscale value of each visual non-edge pixel for final
17 display in direct proportion to an average grayscale value of
18 all visual non-edge pixels in a kernel of pixels, said average
19 grayscale value further comprising:
20 (A) a sum of grayscale values from said all visual non-
21 edge pixels in said kernel of pixels; and
22 (B) said sum divided by a number of said all visual non-
23 edge pixels in a kernel of pixels;
24 (C) said weighting module for executing a weighting
25 subroutine for altering a grayscale value of each
26 visual non-edge pixel for final display in proportion to
27 an average grayscale value of all visual non-edge
28 pixels in said kernel of pixels, said weighting
29 subroutine further comprising:
30 (1) [[(a)]] a FinalGrayScale(i, j) variable;
31 (2) [[(b)]] said FinalGrayScale(i, j) variable storing
32 a grayscale value for final display of each pixel
33 being processed;
34 (3) [[(c)]] a Kernel variable for storing a count of
35 pixels in said kernel of pixels;

(4) [[d]] a SumEdgePixels variable for counting
a number of said visual edge pixels in said
kernel of pixels;

(5) [[e]] a NonEdgeGrayscaleSum variable for
storing said sum of grayscale values of all
visual non-edge pixels in said kernel of pixels;
and

(6) [[f]] wherein said weighting subroutine is
defined as:

$$\text{FinalGrayScale}(i, j) = (1/(\text{Kernel} - \text{SumEdgePixels})) *$$

NonEdgeGrayscaleSum; and

(ii) an edge sharpener for post-processing said edge pixels.

Claim 16 (original): The filter system of claim 1, said edge sharpener
further comprising an unsharp masking module, said unsharp masking module adding a
high pass filtered image of said digital image to said digital image.

Claim 17 (original): The filter system of claim 16, said unsharp masking
module sharpening visual edges in said digital image by an edge sharpening factor λ .

Claim 18 (original): The filter system of claim 16, said high pass filtered
image being obtained by subtracting a low pass filtered image of said digital image from
a scaled version of said digital image.

Claim 19 (currently amended): The filter system of claim 18, A filter
system for post-processing a digital image, said digital image having a plurality of
visual-edge pixels and a plurality of visual non-edge pixels, said filter system
comprising:

- 5 (a) an edge mapper for producing a binary map of said visual edge
6 pixels and said visual non-edge pixels;
7 (b) a pixel sorter comprising:
8 (i) said pixel sorter for reading said binary map; and
9 (ii) said pixel sorter for assigning to each pixel a type of filtration
10 to be provided by said filter system;
11 (c) an adaptive filter for receiving output from said pixel sorter; and
12 (d) said adaptive filter comprising:
13 (i) a de-ringing module for post-processing said visual non-
14 edge pixels; and
15 (ii) an edge sharpener for post-processing said edge pixels said
16 edge sharpener further comprising an unsharp masking
17 module, said unsharp masking module adding a high pass
18 filtered image of said digital image to said digital image, said
19 high pass filtered image being obtained by subtracting a low
20 pass filtered image of said digital image from a scaled
21 version of said digital image, said low pass filtered image for
22 each pixel being processed further comprising:
23 (A) [[(a)]] an EdgeGrayscaleSum variable for storing a
24 sum of grayscale values of all visual edge pixels in a
25 kernel of pixels surrounding said pixel being
26 processed;
27 (B) [[(b)]] a SumEdgePixels variable for counting a
28 number of pixels representing a visual edge in said
29 kernel of pixels surrounding said pixel being
30 processed; and
31 (C) [[(c)]] said low pass filtered image for said pixel being
32 processed being the ratio
33 EdgeGrayscaleSum/SumEdgePixels.

34

- 1 Claim 20 (currently amended): ~~The filter system of claim 16~~ A filter
2 system for post-processing a digital image, said digital image having a plurality of
3 visual-edge pixels and a plurality of visual non-edge pixels, said filter system
4 comprising:
- 5 (a) an edge mapper for producing a binary map of said visual edge
6 pixels and said visual non-edge pixels;
- 7 (b) a pixel sorter comprising:
- 8 (i) said pixel sorter for reading said binary map; and
9 (ii) said pixel sorter for assigning to each pixel a type of filtration
10 to be provided by said filter system;
- 11 (c) an adaptive filter for receiving output from said pixel sorter; and
12 (d) said adaptive filter comprising:
- 13 (i) a de-ringing module for post-processing said visual non-
14 edge pixels; and
- 15 (ii) an edge sharpener for post-processing said edge pixels,
16 said edge sharpener further comprising an unsharp masking
17 module, said unsharp masking module adding a high pass
18 filtered image of said digital image to said digital image, said
19 unsharp masking module for executing a sharpening
20 subroutine, said sharpening subroutine further comprising:
- 21 (A) [[a)] a FinalGrayScale(i, j) variable for storing a
22 grayscale value for final display of each pixel being
23 processed;
- 24 (B) [[b)] a Grayscale(i, j) variable for storing a grayscale
25 value of an individual pixel at coordinates i and j in
26 said digital image;
- 27 (C) [[c)] a SumEdgePixels variable for storing a count
28 of visual edge pixels in said kernel of pixels;

(D) [(d)] an EdgeGrayscaleSum variable for storing a sum of grayscale values of all visual edge pixels in said kernel of pixels; and

(E) [(e)] a selectable λ variable for storing an edge sharpening factor; and

(F) [(f)] wherein said sharpening subroutine is defined as:

FinalGrayscale(i, j) =
(1 + λ) * Grayscale(i, j) - (1/SumEdgePixels) * λ *
EdgeGrayscaleSum.

Claim 21 (original): The filter system of claim 1, said edge sharpener further comprising a limiter for decreasing said edge sharpening to avoid saturation of visual edges.

Claim 22 (original): The filter system of claim 1, said filter system sharing data and calculations between said edge mapper, said pixel sorter, and said adaptive filter to reduce calculations.

Claim 23 (original): A method of filtering signals of a digital image composed of a plurality of pixels, said method comprising the steps of:

- (a) mapping visual edges in said digital image to produce an edge map;
- (b) sorting pixels of said edge map into edge pixels representing visual edges and non-edge pixels representing visual non-edges;
- (c) edge sharpening said edge pixels;
- (d) de-ringing said non-edge pixels; and
- (e) displaying said edge pixels after edge sharpening and said non-edge pixels after de-ringing.

11

1 Claim 24 (original): The method of claim 23, said step of mapping visual
2 edges further comprising the step of mapping visual edges pixel by pixel using at least
3 one edge gradient operator.

4

1 Claim 25 (original): The method of claim 23, said step of sorting pixels of
2 said edge map further comprising the step of sorting each non-edge pixel according to a
3 number of edge pixels in a kernel of pixels surrounding said non-edge pixel.

4

1 Claim 26 (original): The method of claim 23, said step of sorting pixels of
2 said edge map further comprising the step of sorting a non-edge pixel for no filtering if a
3 number of edge pixels in said kernel of pixels surrounding said non-edge pixel is greater
4 than a selected threshold.

5

1 Claim 27 (original): The method of claim 23, said step of de-ringing said
2 non-edge pixels further comprising the steps of:

- 3 (a) averaging grayscale values of pixels in said kernel of pixels
4 surrounding each non-edge pixel; and
5 (b) altering a grayscale value of each non-edge pixel in proportion to
6 averaged grayscale values of said pixels in a kernel of pixels
7 surrounding each non-edge pixel.

8

1 Claim 28 (original): The method of claim 23, said step of de-ringing non-
2 edge pixels further comprising the step of de-ringing using at least some data previously
3 calculated in said steps of mapping and sorting.

4

1 Claim 29 (original): The method of claim 23, said step of edge sharpening
2 further comprising the step of unsharp masking each edge pixel by adding a high pass
3 filtered image of said edge pixel to an original image of said edge pixel.

4
1 Claim 30 (original): The method of claim 23, said step of edge sharpening
2 further comprising the step of edge sharpening using at least some data previously
3 calculated in said steps of mapping, sorting, and de-ringing.

4
1 Claim 31 (original): A method for post-processing a digital image having a
2 plurality of pixels, said method comprising the steps of:

- 3 (a) edge mapping edge pixels representing visual edges and non-edge
4 pixels representing visual non-edges in said digital image to
5 produce a binary map of edge mapped individual pixels;
6 (b) sorting said edge mapped individual pixels for different types of
7 filtration;
8 (c) filtering sorted individual pixels adaptively, said step of filtering
9 comprising the steps of:
10 (i) edge sharpening said edge pixels; and
11 (ii) de-ringing said non-edge pixels;
12 (d) wherein said steps of edge sharpening and de-ringing may be
13 performed substantially simultaneously.

14
1 Claim 32 (original): The method of claim 31, said step of sorting further
2 comprising the steps of:

- 3 (a) designating a group of pixels surrounding and including each non-
4 edge pixel being sorted;
5 (b) reading a grayscale value of each pixel in said group of pixels;
6 (c) omitting said de-ringing and said edge sharpening for said non-
7 edge pixel if said group of pixels includes at least a selected
8 minimum number of edge pixels; and
9 (d) de-ringing said non-edge pixel if said group of pixels does not
10 include at least a selected minimum number of edge pixels.

11

1 Claim 33 (original): The method of claim 32, said step of de-ringing further
2 comprising the step of scaling for display said grayscale value of each non-edge pixel
3 sorted for de-ringing in proportion to averaged grayscale values of non-edge pixels in
4 said group of pixels.

5

1 Claim 34 (original): The method of claim 31, said step of edge sharpening
2 further comprising the step of unsharp masking an edge pixel by adding a high pass
3 filtered image of said edge pixel to an original image of said edge pixel.

4

1 Claim 35 (original): A filter system for post-processing a digital image,
2 said digital image having a plurality of visual-edge pixels and a plurality of visual non-
3 edge pixels, said filter comprising:

- 4 (a) edge mapping means for producing a binary map of said visual
5 edge pixels and said visual non-edge pixels;
6 (b) pixel sorting means for assigning visual non-edge pixels to a de-
7 ringing means and edge pixels to an edge sharpening means;
8 (c) said de-ringing means for post-processing said visual non-edge
9 pixels; and
10 (d) said edge sharpening means for post-processing said edge pixels.

11

1 Claim 36 (original): The filter of claim 35, said edge mapping means
2 further comprising edge detecting means.

3

1 Claim 37 (currently amended): A filter system for post-processing a digital
2 image, said digital image having a plurality of pixels, said filter system comprising:

- 3 (a) an edge mapper for producing a binary map of said plurality of
4 pixels;

- 5 (b) a pixel sorter for sorting pixels of said digital image into categories
6 for appropriate post-processing;
- 7 (c) a first post-processing module for post-processing a first category
8 of said plurality of pixels, said first post-processing module is a de-
9 ringing module and said first category is non-edge pixels; and
- 10 (d) a second post-processing module for post-processing a second
11 category of said plurality of pixels, said second post-processing
12 module is an edge sharpening module and said second category is
13 edge pixels.

14
1 Claim 38 (cancelled):
2

1 Claim 39 (cancelled):
2

1 Claim 40 (original): The filter system of claim 37 further comprising a third
2 post-processing module for post-processing a third category of said plurality of pixels,
3 wherein said third post-processing module is a non-filter.
4

1 Claim 41 (new): The filter system of claim 1, wherein said de-ringing
2 module and said edge sharpener operate substantially simultaneously.
3

1 Claim 42 (new): The method of claim 23, wherein said step of edge
2 sharpening is performed substantially simultaneously with said step of de-ringing.
3

1 Claim 43 (new): The filter of claim 35, wherein said de-ringing means and
2 said edge sharpening means operate substantially simultaneously.
3

Application No. 09/881,384
Amendment dated June 26, 2004
Reply to Office action of March 24, 2004

1 Claim 44 (new): The filter system of claim 37, wherein said first post-
2 processing module and said second post-processing module operate substantially
3 simultaneously
4